Energy Conservation in Buildings and Community Systems Programme (ECBCS)

INTERNATIONAL ENERGY AGENCY

Introduction to IEA ECBCS Programme and ECBCS Annex 46

Alexander Zhivov
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Helsinki, Finland
October 5, 2005

What is IEA Energy Conservation in Buildings and Community Systems Program?

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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- Collaborative R&D Agreement (since 1977)
- Twenty two countries
- 48 Research Projects (38 completed)
- Focus on extensive technology transfer, addressing design and building environment, building technologies and systems/products

What is the IEA ?
- Organisation of R&D Collaboration

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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International Energy Agency (IEA)

Governing Board

Standing Committee
Committee on Energy Research & Technology (CERT)

- **Working Party on Energy End-Use Technologies**
  - **Energy Conservation in Buildings and Community Systems Programme**
- Working Party on Renewable Energy Technologies
- Working Party on Fossil Fuel Technologies
- Fusion Power Co-ordinating Committee

ECBCS Strategic Plan 2002-2007 - Strategies of the Programme

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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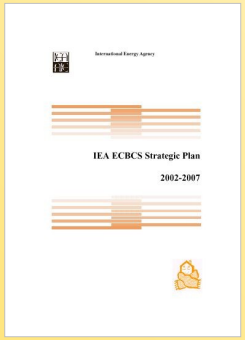
Building Technologies and Systems (Products) (1 of 3):

- Develop innovative materials and related-knowledge on the environmental impacts of building materials and envelopes, which will assist in the design and construction process.
- Improve thermal performance of building envelopes to minimize cooling and heating loads, and integrate solutions with other buildings.
- Improve the performance and energy-efficiency of HVAC and lighting systems, and optimize integrated solutions.



ECBCS Strategic Plan 2002-2007 - Strategies of the Programme

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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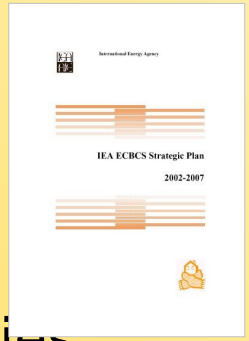
Building Technologies and Systems (Products) (2 of 3):

- Develop and implement scientifically based methods to reduce ventilation loads, and improve indoor air quality.
- Develop, demonstrate, and implement advanced and user-driven energy management, intelligent buildings, and control systems though advances in sensor technology, wireless technologies, system interface, and users' needs
- Strategy: Introduce cost effective retrofit concepts for buildings with the newest energy saving technologies



ECBCS Strategic Plan 2002-2007 - Strategies of the Programme

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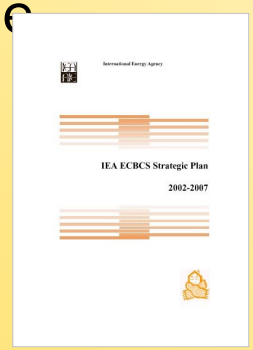
Building Technologies and Systems (Products) (3 of 3):

- Assess feasibility of low-energy concepts and optimize collaboration with IEA SHC on use of renewable energy sources in buildings
- Develop and demonstrate innovative concepts and systems, for local integrated power, cooling and heating generation and distribution systems, in collaboration with other BRIAs (e.g., Energy Storage, District Heating, and Demand-side Management)



ECBCS Strategic Plan 2002-2007 Products

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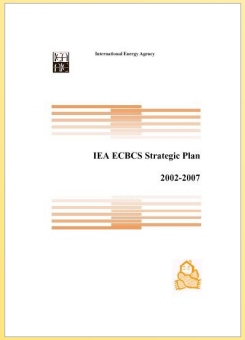
Products of the collaborative R&D work are:

- Design guides
- Design methodologies, tools, software
- Performance analysis, methods and tools
- Generic energy saving technologies, e.g. building and system concepts
- Demonstration, system analysis and assessment
- Information packages, technical reports
- Conferences, symposia, workshops



ECBCS Completed Annexes (1 of 4)

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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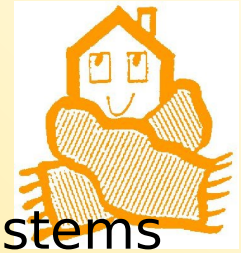

- Annex 1 Load Energy Determination of Buildings
- Annex 2 Ekistics and Advanced Community Energy Systems
- Annex 3 Energy Conservation in Residential Buildings
- Annex 4 Glasgow Commercial Building Monitoring
- Annex 6 Energy Systems and Design of Communities
- Annex 7 Local Government Energy Planning
- Annex 8 Inhabitant Behaviour with Regard to Ventilation
- Annex 9 Minimum Ventilation Rates
- Annex 10 Building HEVAC Systems Simulation
- Annex 11 Energy Auditing
- Annex 12 Windows and Fenestration

ECBCS Completed Annexes (2 of 4)

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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- Annex 13 Energy Management in Hospitals
- Annex 14 Condensation and Energy
- Annex 15 Energy Efficiency in Schools
- Annex 16 Building Energy Management Systems - User Interfaces and System Integration
- Annex 17 Building Energy Management Systems- Evaluation and Emulation Techniques
- Annex 18 Demand Controlled Ventilation Systems
- Annex 19 Low Slope Roof Systems
- Annex 20 Air Flow Patterns within Buildings
- Annex 21 Environmental Performance
- Annex 22 Energy Efficient Communities

ECBCS Completed Annexes (3 of 4)

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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- Annex 23 Multi-zone Air Flow Modeling
- Annex 24 Heat, Air and Moisture Transport
- Annex 25 Real Time HVAC Simulation
- Annex 26 Energy Efficient Ventilation of Large Enclosures
- Annex 27 Evaluation and Demonstration of Domestic Ventilation Systems
- Annex 28 Low Energy Cooling
- Annex 29 Daylighting in Buildings
- Annex 30 Bringing Simulation Models to Engineers
- Annex 31 Energy Related Environmental Impact of Buildings
- Annex 32 Integral Building Envelope Performance Assessment
- Annex 33 Advanced Local Energy Planning

ECBCS Completed Annexes (4 of 4)

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- Annex 34 Computer-aided Evaluation of HVAC System Performance
- Annex 35 Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings (Hybvent)
- Annex 36 Retrofitting in Educational Buildings - Energy Concept Advisor for Technical Retrofit Measures
- Annex 37 Low Exergy Systems for Heating and Cooling of Buildings
- Annex 38 (Solar) Sustainable Housing
- Annex 39 High Performance Insulation Systems
- Annex 40 Commissioning of Building HVAC Systems for Improved Energy Performance

ECBCS On-Going Annexes (1 of 2)

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- Annex 5 Air Infiltration and Ventilation Centre
- Annex 38 (Solar) Sustainable Housing
- Annex 39 High Performance Insulation Systems
- Annex 40 Commissioning of Building HVAC Systems for Improved Energy Performance
- Annex 41 Whole building heat, air and moisture response (MOIST-ENG)
- Annex 42 The Simulation of Building-Integrated Fuel Cell and other Cogeneration Systems (GOGEN-SIM)
- Annex 43 Testing and Validation of Building Energy Simulation Tools (in conjunction with IEA Solar Heating & Cooling)

ECBCS On-Going Annexes (2 of 2)

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- Annex 44 Integrating Environmentally Responsive Elements in Buildings
- Annex 45 Energy Efficient Electric Lighting for Building
- Annex 46 Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Governments Buildings
- Annex 47 Cost-Effective Commissioning of Existing and Low-Energy Buildings
- Annex 48 Prefabricated Systems for Low Energy/ High Comfort Building Renewal

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Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) – Annex 46

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Annex 46 Scope

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Government non-residential buildings, e.g.:

- **office/administrative buildings,**
- **dormitories/barracks**
- **one storey production and**
- **maintenance facilities**

Annex 46 Target Groups

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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- Building energy managers
- Architects, Building, Process and Energy Systems Designers
- Energy Services Companies
- Energy auditors
- Executive decision-makers

Annex 46 Objectives

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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- To provide tools and guidelines to improve the working environment of Government buildings through energy-efficient retrofitting projects. Many results can be applied to similar private and public sector buildings;
- To promote energy- and cost-efficient retrofit measures by providing successful examples;
- To support decisionmakers in evaluating the efficiency and acceptance of available concepts;
- To find improved ways of using Energy Performance Contracts (ESPCs) for Government buildings retrofit measures.

Annex 46* Has Four Subtasks Addressing

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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A. Energy Assessment Protocol (Canada, Denmark, Finland,VTT, Germany, Poland, Russia, USA)

B. Technology Database (Canada, Denmark, Cenergia, Finland, Germany, Italy, Poland, Russia, Slovakia, UK, USA)

C. Business Guidelines (Denmark, Finland, Germany, USA, ORNL)

D. Energy Concept Adviser Toolkit "EnERGo" (Canada, Denmark, Finland, Germany, Fraunhofer Institute, Italy, Poland, Russia Slovakia, UK, USA)

Subtask A: Develop an energy assessment and analysis methodology/protocol "Energy Assessment Guide for Energy Managers and ESCOs":

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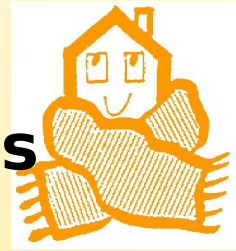

- **Analysis of best practices and procedures of identifying energy conservation opportunities in retrofitted Government buildings**
- **Development of a consensus protocol for conducting energy assessments at Government administrative/office buildings and production and maintenance facilities**

Installation-wide and Building Energy Usage and Waste

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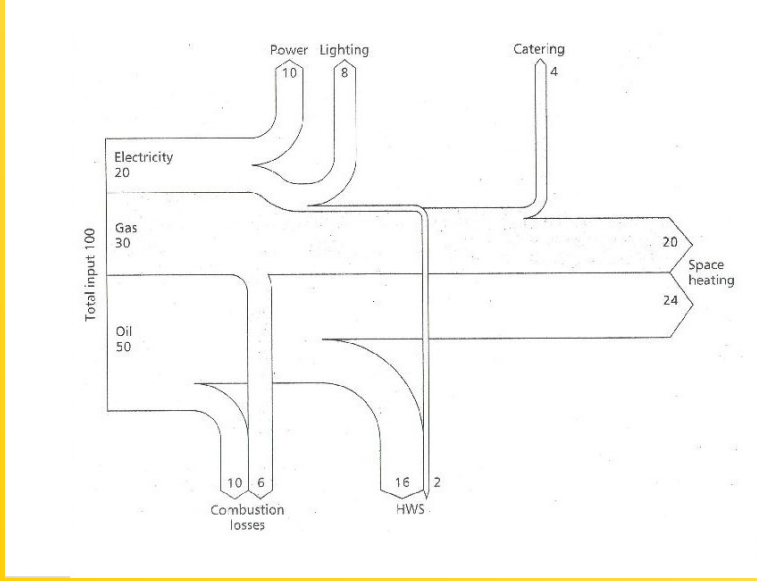
SANKEY diagram showing how energy supplied to the post is used and where it is wasted, e.g.,:

- **In the power plant (for a CWS and HWS)**
- **Combustion losses with flue gases**
- **Power generation**
- **Heat losses in distribution system**
- **Outdoor lights**
- **Building energy systems**

Building energy systems

- **Heating,**
- **Cooling**
- **Ventilation**
- **Compressed Air**
- **Water**
- **Sewage**
- **Process**
- **Lights**



Subtask A Timeline

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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Milestones **Timeline**

- **A1. Review and analyze best practices** **1-6 months**
- **A2. Prepare a draft of industrial protocol** **1-7 months**
- **A3. Review the draft prepared in A2 and prepare the consensus document** **13-24 months**
- **A4. Prepare a draft of non-ind. protocol** **13-18 months**
- **A5. Review the draft prepared in A5 and prepare the consensus document** **19-24 months**
- **A6. Finalize protocols prepared in A3 and A5** **24-30 months**
- **A7. Conduct at least 3 show-case energy assessments in two or more countries to demonstrate protocols** **12-36 months**

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<u>Subtask B</u>: Develop a database of "Energy Saving Technologies and Measures for Government Building Retrofits" with examples of best practices:

- Analysis of series of best practice examples of retrofitted buildings
- Development of a list of promising energy saving technologies and measures, identify screening tools and conduct screening for representative conditions
- Technical and LCC analysis of energy saving technologies and measures for different climatic conditions and energy costs;
- Development of a data-base supported by examples of good-practices/show case descriptions

Subtask B Timeline

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Milestones **Timeline**

- **B1. Develop a List of ECMs 1-18 months**
- **B2. Model buildings and Simulation assumptions 1-6 months**
- **B3. ECMs description 1-12 months**
- **B4. ECMs screening 7-24 months**
- **B5. Case Study descriptions 13-30 months**
- **B6. Report 31-36 months**

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Subtask C: Develop "Best-Practice Guidelines for Innovative Energy Performance Contracts"

- Analysis and summary of ESPC best practice agreements and financial options
- Baseline development
- Measurement and verification of savings
- Technical assistance in EPC development
- Financing, price reasonableness of ECMs,
- Performance period administration

Subtask C Timeline

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Milestones Timeline

- **C1. Identification of common goals and motivating factors for the use of EPC in government buildings, and criteria for use of EPC vs. other funding mechanisms 1-10 months**
- **C2. Analysis of EPC contract structures and contract development processes to identify barriers and suggest potential improvements 11-18 months**
- **Comparison of technical/engineering practices in the areas baseline development, estimation of energy and cost savings, and measurement and verification of savings, to identify those techniques that have been most successful in participating countries to meet their goals 18-28 months**
- **Guidelines development 28-36 months**

Subtask D: Develop IT-Toolkit “EnERGo”

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IT Tool-kit “EnERGo“ based on the Energy Concept Adviser (ECA) - an electronic interactive source book – will include all Annex results and will allow users to obtain extensive information, according to their individual focus of interest:

- **energy saving opportunities,**
- **design inspirations,**
- **design advice,**
- **decision tools,**
- **design tools,**
- **commissioning methods,**
- **long term monitoring systems and measures that require no financial investment.**

Subtask D Timeline

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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Milestones **Timeline**

- D1. Analysis of codes/engines to be implemented 1-6months
- D2. Definition of standardized interface protocols for in-output and user interface 6-18 months
- D3. Extended Technologies and Case-studies viewer (based on the info from subtask B) 6-36 months
- D4. Development of default values (building types, constructions, mech. systems, costs, climates, etc.) 12-36 months
- D5. Alpha version 30 month
- D6. Beta version 36 month
- D7. National evaluation and final version 36-48 months

Annex 46 Deliverables

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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- Energy Assessment Guide for Energy Managers and ESCOs
- Retrofit data base with the results of the analysis
- Best-practice guidelines for innovative energy performance contracts
- IT-Toolkit “EnERGo” – Energy Concept Adviser

Participants

Country	Organization	Contribution
Canada	Public Works	Subtasks A,B,D
Denmark	Cenergia	Subtasks A,B,C,D
	SBI	Subtasks A,D
	Int. Center for Indoor Environment and Energy	Subtask B
Finland	Technical Research Centre of Finland/VTT	Subtasks A, B,C,D
Germany	Fraunhofer Institute of Building Physics	Subtask B,C,D
	Ennovatis, GmbH	Subtask A,C,D
	Schiller Engineering	Subtask A
Italy	Politechnico Milano	Subtask B,D
Poland	FEWE	Subtasks A,,B(Obsr), D
Russia	ABOK	Subtask B, D (Obsr)
	CRIIB	Subtasks A, B,D(Obsr)
	CENEF	Subtasks A, B, D
Slovakia	Slovak University of Technology	Subtasks B,D
UK	University of Strathclyde / Energy Systs Res. Unit (ESRU)	Subtasks B,D
USA	US Army Corps of Engineers, ERDC	Subtasks A,B,C,D
	US Army Corps of Engineers	Subtasks A,B,C
	NAVFAC	Subtasks A, B
	Oak Ridge National Laboratory	Subtasks C
	Oklahoma State University	Subtask B
	University of Illinois, Chicago	Subtasks A,B
	Johnson Controls, Inc.	Subtask B
	Plymovent Corp	Subtask B

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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USACE ERDC (USA) - Operating Agent
Finland – Subtask A leader
Denmark – Subtask B leader
ORNL (USA) – Subtask C leader
Fraunhofer Institute (Germany) – Subtask D leader

First Annex 46 planning workshop "Energy Efficiency in Government Buildings" Orlando (USA) February 4-6, 2005

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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70 participants from 8

- **Shared information and ideas in a collegial forum**
- **Provided technical and methodological support to energy managers, designers, and Energy Saving Companies**
- **Provided a forum to prepare the detailed Program of Work, select subtasks leaders and distribute tasks for the IEA ECBCS Annex 46 "Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)**

Second Annex 46 Workshop
Chicago, IL (USA), January 19-20, 2006

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- Co-sponsored by DOD, DOE and ASHRAE
- Main audience: energy managers, contractors, researchers, manufacturers, and decision makers from the government sector.
- The Workshop agenda will include:
  - National and International Energy Conservation in Buildings Programs, Directives and Guidelines
  - Energy Conservation Technologies and Measures for new buildings and building retrofits
  - Presentation of first deliverables resulted from the Annex 46.
- Will precede the winter ASHRAE 2006 meeting and technology show

Second Annex 46 planning meeting Berlin (Germany) May 23-25, 2005

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- 15 participants from 8
- Finalized the work plan for each four subtasks
- Identified new participating countries/organizations and their contributions to the new IEA ECBCS Annex 46
- Identified first preliminary steps in execution of subtasks
- The next working? meeting will be in Helsinki, Finland on October 5-8, 2005)

Third Annex 46 planning meeting and a workshop Helsinki (Finland) October 5-7, 2005

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

INTERNATIONAL ENERGY AGENCY

60 participants from 8

- Shared information and ideas in a collegial forum sponsored by VTT, US DOE, Annex 46, ABOK, and CENEF
- Finalized the work plan for each four subtasks
- Identified time budget specific contributions from each participating country/organization to the new IEA ECBCS Annex 46
- Identified next steps in execution of subtasks

Ms for office buildings and barracks/ dormitories to be screened in CY05

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- Replace windows non-operable (VLT 0.5-0.7, neutral color glazing, SHGC > 1.55)
- Replace windows with operable and similar characteristics as in (1)
- Based on (2), use hybrid ventilation (mechanical in hot and cold seasons, natural - during mild seasons)
- Cool roofs – new and re-roofing projects
- Insulate roofs while conducting re-roofing project
- Solar walls.
- Replace entrance doors with a better insulated and sealed
- Install vestibules
- Install windbreakers when vestibule is impossible]
- Insulate attic
- Ventilate attic

- Exterior window shading (light shelves)
- Exterior window shading (vertical fins)
- Exterior window shading (planting trees)
- Skylights (Solar tubes)
- Night pre-cooling
- Dimming controls for daylight harvesting
- Reduce duct leakage
- Insulate supply and return ducts
- Roof spray cooling
- Insulate hot/cold water pipes

ECMs for office buildings and barracks/ dormitories to be screened in CY05,cont.

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- Separate ventilation system and AC system (DOAS and similar)
- Replace window AC with a central air system
- Replace window AC with a DX split system
- Exhaust heat recovery with an enthalpy wheel
- Exhaust heat recovery with a heat pipe
- Direct evaporative cooling
- Indirect evaporative cooling
- Hydronic heating/cooling with radiant panels
- Hydronic heating with convectors
- Demand control CO2 sensors
- Replace existing lights with T8 and instant start ballasts
- Add task lighting
- Install occupancy sensors
- Install floor heating (hydronic or electric)
- Thermal energy ice storage
- Thermal energy cold water storage
- Replace steam/hot water AHU heaters for indirect gas-fired heaters
- Replace motors with a premium efficiency motors
- Re-arrange systems to create zones (e.g., perimeter and core, by facade)
- HVAC weekend setback temperature

Temperature on the Surfaces of Absorbing Roofs (OAT = 34°C)

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Cool and Standard Brown Metal Roofs

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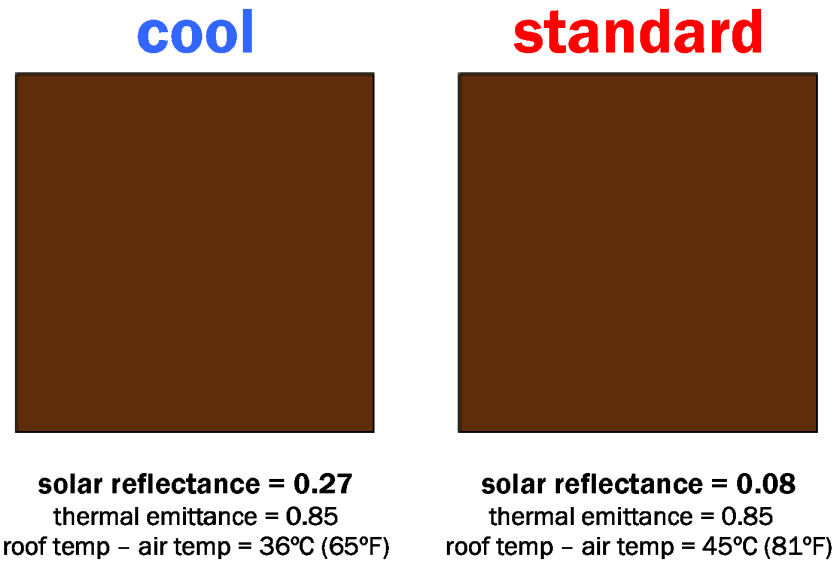
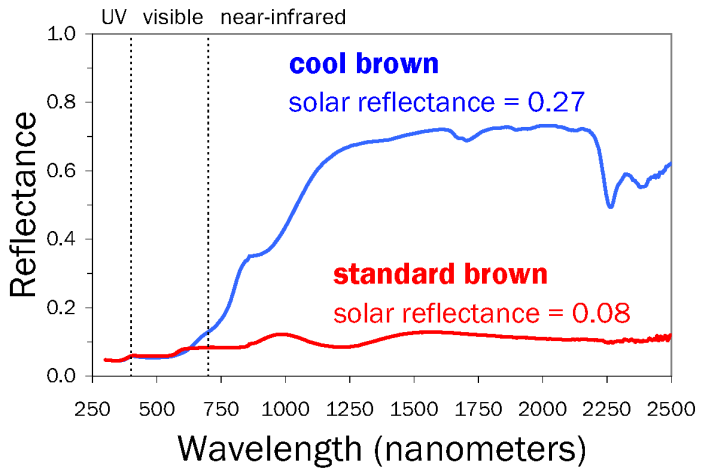
Cool brown 9ºC cooler than standard brown

brown metal panel

COURTESY BASF CORPORATION


cool
standard
solar reflectance = 0.27
thermal emittance = 0.85
roof temp – air temp = 36ºC (65ºF)
solar reflectance = 0.08
thermal emittance = 0.85
roof temp – air temp = 45ºC (81ºF)



Cool and Standard Green Metal Roofs

Cool green 7ºC cooler than standard green

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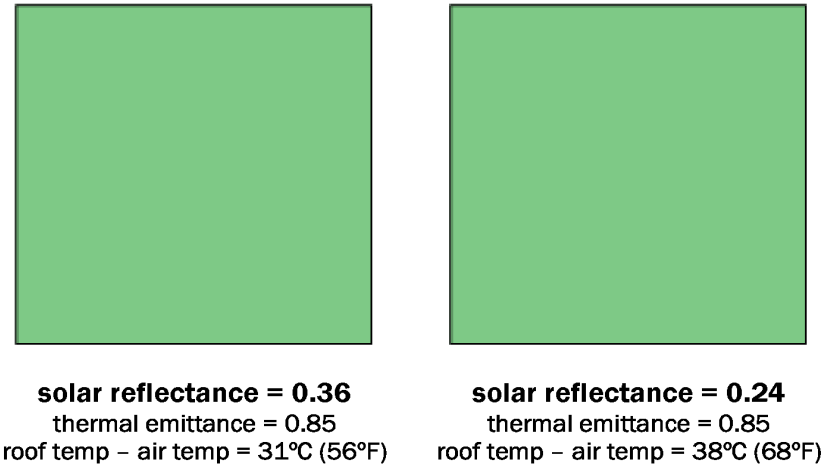
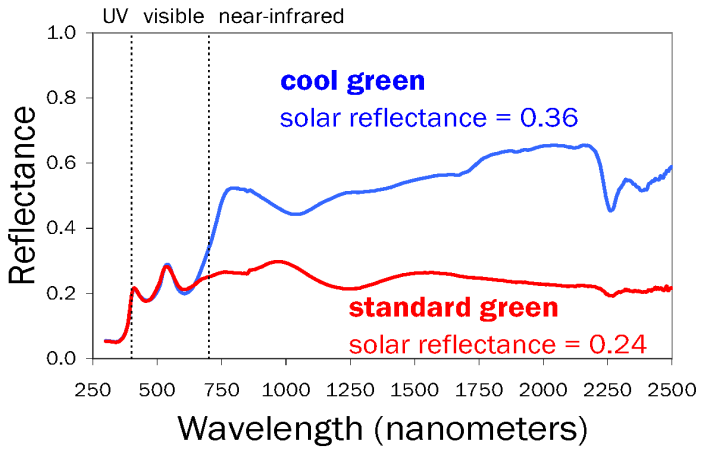
green metal panel

COURTESY BASF CORPORATION


cool
standard
solar reflectance = 0.36
thermal emittance = 0.85
roof temp – air temp = 31ºC (56ºF)
solar reflectance = 0.24
thermal emittance = 0.85
roof temp – air temp = 38ºC (68ºF)



Solar Wall

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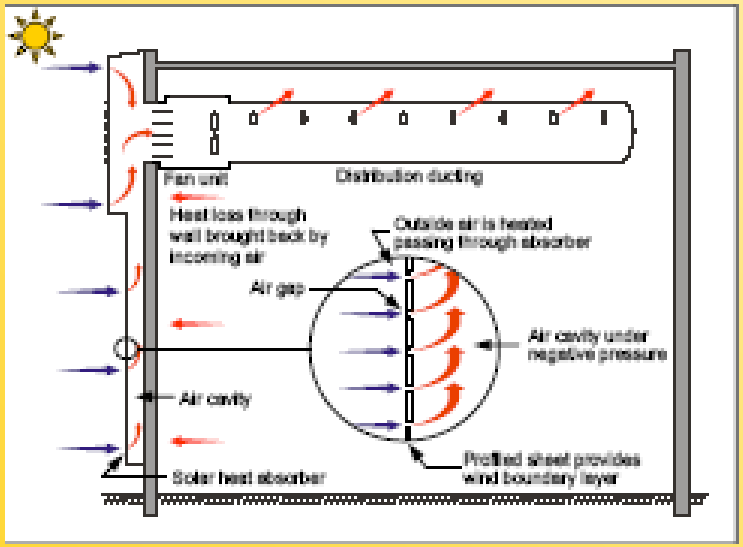
Fan unit
Distribution ducting
Heat loss through wall brought back by incoming air
Outside air is heated passing through absorber
Air gap
Air cavity under negative pressure
Air cavity
Profiled sheet provides wind boundary layer
Solar heat absorber

A transpired solar collector to preheat make-up air

Ft Carson hangar first Fed facility with solar wall (FY96)

$140K retrofit cost

$11K/yr gas savings

Industrial ECMs to be Screened in CY05, cont.

SUPPORT SYSTEMS

- **LIGHTING**
  - **Install task/spot lighting at work places**
  - **Install lighting tubes**
  - **Replace high-intensity discharge lamps with high-intensity fluorescent lamps**
  - **Replace incandescent lamps with compact fluorescent lamps (CFLs)**
  - **Replace incandescent or fluorescent exit lamps with light emitting diodes (LEDs)**
  - **Use natural lighting**
- **MOTORS/ELECTRICAL SYSTEMS**
  - **Replace motors with a premium efficiency motors**
  - **Replace belts with a high efficiency belts**
  - **Use properly sized motors for applications**
  - **Replace old lightly loaded transformers**
- **COMPRESSED AIR**
  - **Compressed air management program**
  - **Compressed air leak management program**
  - **Reduce compressed air system pressure**
  - **Reduce inappropriate uses of compressed air**
  - **Air compressor heat recovery**

Industrial ECMs to be Screened in CY05

Energy Conservation in Buildings and Community Systems Programme (ECBCS)

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HVAC

- Use displacement ventilation/temperature stratification on shops with excessive heat in summer
- Use de-stratification fans or high velocity nozzles in winter
- Use recirculating air in summer to reduce cooling loads
- Replace forced-air/steam air heating units with radiant gas heaters
- Use DEC(a), IDEC (b) and DEC/IDEC(c) for cooling plant air in summer
- Use natural gas heating to replace steam/hot water heating in central AHU
- Enclose process/optimize existing hood design for optimal performance (airflow rate)
- Solar wall for outdoor air preheating

BUILDING ENVELOPE

- Replace roofs using “cool roof” technology
- Vestibules for large opening
- High-speed roller doors for large openings
- Reduce leaks through the building envelope

Industrial ECMs to be Screened in CY05, cont.

MANUFACTURING ENERGY CONSERVATION

MAINTENANCE/REPAIR SHOPS

- **Install close capture vehicle exhaust for moving/stationary vehicles**

METAL CASTING

- **Install static frequency converters on the induction furnaces**
- **Install Acutrak electric melting system for aluminum and nonferrous metals**
- **Replace switchgear system with advanced insulated gate bipolar transistor (IGBT) converters**
- **Adopt molten metal blanketing (MMB)**

METAL FINISHING

- **Insulate high temperature plating tanks**
- **Install covers on chromium plating tanks**
- **Use plating fixtures allowing for reduction of plating time and labor for parts masking**

PAINTING

- **Utilize infrared/UV paint curing (HVAC)**
- **Reduce air flow in paint booth by using VFDs**
- **Energy recovery in paint booths (HVAC)**

Industrial ECMs to be Screened in CY05, cont.

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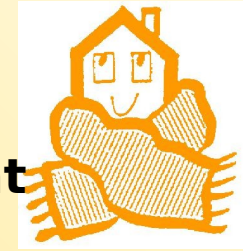

CONTROLS

- **Install VFD drives to balance HVAC system with a flexible production (number of production equipment pieces and exhausted airflow changes) (HVAC)**
- **Use setback thermostats**
- **Turn-off equipment when not in use (no idling motors, etc.) (Motors, Compressed air, all processes)**
- **Optimize AHU running time vs. occupancy time**
- **Balance ventilation and production shops (per 1,000 cfm of infiltrating air)**

Industrial ECMs to be Screened in CY05, cont.

MANUFACTURING ENERGY CONSERVATION

- **HEAT TREAT**
  - **Heat recovery from air exhausted from heat-treatment ovens**
  - **Adopt atmospheric plasma microwave heat treating**
  - **Adopt ausforming as a heat treat and grinding procedure**
  - **Incorporate a heat-treating planning system for batch furnaces**
- **WELDING**
  - **Demand based local exhaust system for welding shops (HVAC)**
  - **Reduce fumes/ventilation air with GMAW or FCAW pulse welding**
  - **Reduce fumes/ventilation air with Low-Fume Welding Cored Wires**
  - **Reduce fumes/ventilation air by suing shield gas with low C02 content**

Industrial Facilities Heating

Unit Hot Water Heaters

Radiant Heaters

Portable Gasoline Fired Heaters

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Plating Tank Cover

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Some Energy Conservation Measures for a Weld

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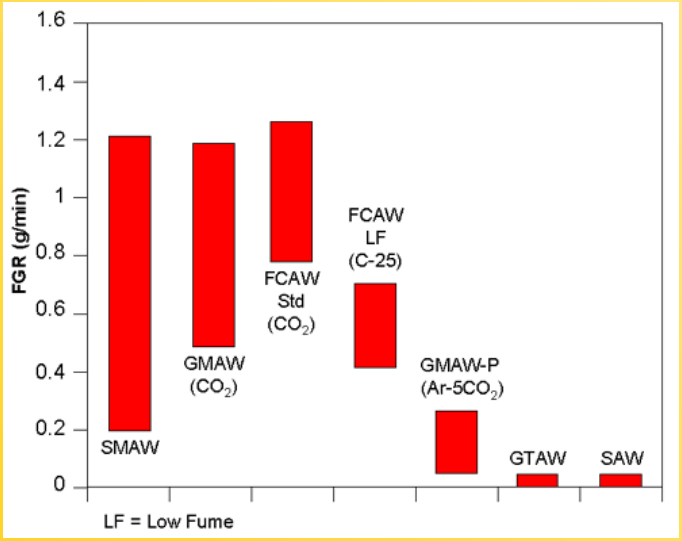
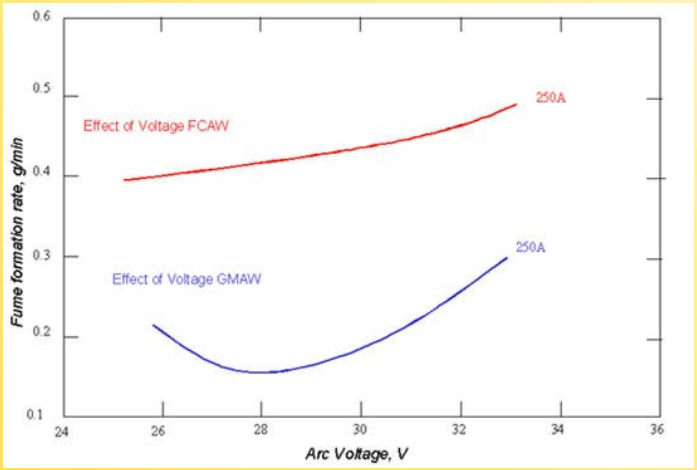
Weld Process Selection

Optimize Voltage





Optimize Shielding Gas

- 100% CO_2
- 75% Ar-25% CO_2
- 90% Ar-10% O_2
- 95% Ar-5% CO_2
- 98% Ar-2% O_2

Increasing Oxidizing Potential

Increasing Fume

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Contact Information

https://kd.erdc.usace.army.mil/projects/ecbcs

http://www.ecbcs.org/annexes/annex46.htm

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Thank you